TECHNOLOGY UPDATE

## WHAT IS BROADBAND RADAR?

You may have seen advertisements and reviews for Navico's "Broadband Radar", that "transmits at 1/20,000 the power of traditional radar, using less than one tenth of the energy of a mobile phone"[1]. Is this possible? Does it really work? Is it really safer than "conventional radars"? The answer to all of these questions is probably yes. To understand why and what are the benefits, we need to understand a little about how these two types of radar work. And we do need to know the difference between power[2] and energy[3] so that we can understand the bunkum in the quote.

## HOW DOES CONVENTIONAL RADAR WORK?

Many people understand how conventional radar works: it transmits a narrow pulse of electromagnetic (in this case radio) energy from its directional antenna. A tiny amount of that energy is reflected back by a target, such as a ship, towards the antenna where a very sensitive receiver amplifies the echo and displays it on a screen. The radio waves travel at the speed of light and so, by measuring the time delay between transmission of the pulse and reception of the echo, it is possible to calculate the distance of the target. Since the transmitted energy is directed into a narrow beam, we know that the target is located somewhere within that beam at a distance we've just calculated. As conventional radars alternate between transmitting and receiving, they are also known as pulse radars.

In order to be able to distinguish between targets at similar distances ("ranges"), the transmit pulse must be short, so that echoes from two closely spaced targets can be separated, or resolved. However, in order for the echo to be sufficiently strong to be detected, the transmit pulse must be very powerful.

To give you some idea of the numbers, the transmit pulses of a typical recreational marine radar are 2.4 kW (or 2,400 watts) but last for about 100 billionths of a second. The total energy in a single pulse is therefore around a quarter of a millijoule and the beam width a little less than five degrees.

## BROADBAND RADARS

We've seen that a conventional, or pulse, radar is able to detect a target with less than a millijoule of energy in each transmit pulse. We can deliver that same energy in a different way: by lengthening the pulse and reducing its power. Let's use the numbers in the quote in the first paragraph. Now the transmitted power is not 2.4 kW but 1/20,000th of that, which is about one tenth of a watt. The pulse duration must be increased by the same factor to about two thousandths of a second so that the transmitted energy remains the same. Unfortunately, it appears our ability to distinguish between two closely spaced targets is reduced by a similar factor, from 25 m to around 50 km, which is unlikely to be very useful!

Not so fast! Let's be smart and impress some modulation onto the transmit pulse, say a frequency modulated signal.

Once we change the frequency of the continuously transmitted pulse in some specific way we can correlate the frequency modulation of the echo with the frequency modulation of the transmit pulse and, bingo, we reduce the range resolution to less than the transmit pulse width – much less, in fact. If we are careful with our radar design, we can recover the loss in range resolution of more than a factor of 20,000.

## BENEFITS OF BROADBAND

So what have we achieved by all this? We've certainly complicated the transmitter and receiver by modulating the transmit pulse and monitoring the modulation of the echo. With modern digital electronics, the additional cost is minor. Importantly, we have vastly reduced the power we need to transmit and this is very significant.

In order to generate the enormous power required by pulse radar, we need special devices, called magnetrons, which in turn require very high voltages to be supplied to them. On the other hand, our "broadband" radar is able to use much less expensive solid state devices (transistors) and power supplies. There is no warm up time required by the transistors and the radar is probably more reliable.

So, we've traded magnetrons for transistors, high voltage power supplies for low and added some (digital) signal processing. Expect the cost to be markedly lower and reliability better.

The Navico radar is a "Frequency Modulated Continuous Wave" radar, that is, the frequency of the transmit pulse linearly increases throughout the pulse. Military radars use much more sophisticated modulation methods. By the way, the Global Positioning System, GPS, uses a similar method, but with a very different (digital) modulation technique.

The Navico radar (under the Simrad, Lowrance and Eagle brand) is optimised for high resolution at short range and, as you can see in the images, can be used for discriminating between individual vessels and berths in a marina. I understand that the price is very competitive too.

## WHERE TO FROM HERE?

Logically, we would expect other manufacturers to offer low power radars. However, intellectual property ownership restrictions, as well as military technology controls, may restrict options for manufacturers. Time will tell. Certainly, modulated pulse radars are the way of the future and, if western manufacturers are unable to provide then, I am sure the developing world will.

***Owen Mace (Cygnus II)***

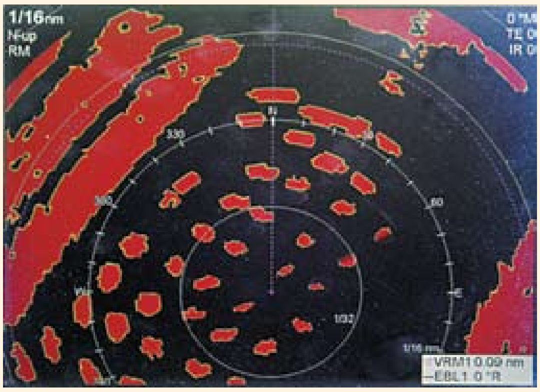
**References and Footnotes**

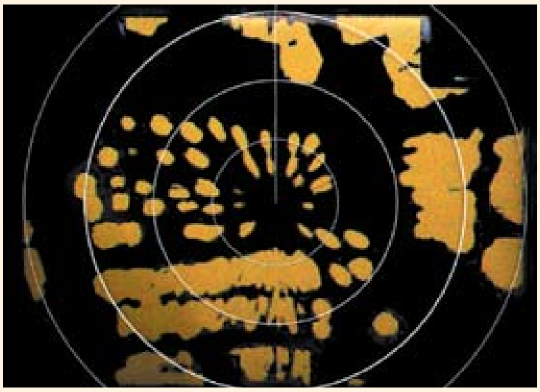
1 www.boatpoint.com.au/news/2009/new-wave-recreational-marine-radar-14730
2 Google "define: energy" or for a more detailed explanation search for "energy" in Wikipedia
3 Google "define: power" or search for "power" in Wikipedia
4 (see sidebar) Google "define: modulation" or search for "modulation" in Wikipedia
5 (see sidebar) en.wikipedia.org/wiki/Jindalee_Operational_Radar_Network

***Please send any technical or scientific articles or updates, of interest to fellow boaties, to the Groundswell editorial team.***

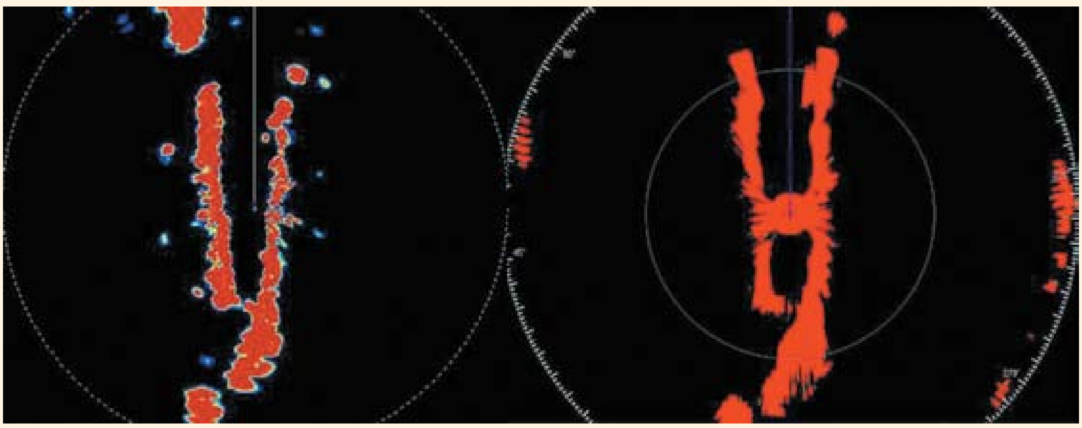
# BROADBAND RADAR

*There are two microwave antennas (one on top of the other) inside the antenna dome of the Navico Broadband Radar. One transmits while the other receives, unlike a conventional radar that only has one antenna used alternately to transmit and then receive.*





*In screen shots provided by Navico's publicity department, Frequency Modulated Continuous Wave (FMCW) technology appears to provide much clearer close up echoes on the left taken within a marina and on the right comparative radar screen shots between FMCW Radar on the left and conventional radar on the right showing echoes from a narrow waterway. Since the Broadband Radar is optimised for short range target detection and Conventional Pulse Radar favour long range target detection, future sea trials should prove interesting.*



## Power and Energy

Power and energy are two closely related terms and are often confused, so here's an explanation.

Energy (symbol J) is the capacity of a physical system to do work and can take a wide variety of forms. Some examples where the energy might be quoted are the energy in a fuel tank, the energy per litre of fuel, energy stored in a battery or the energy required to move your boat from the Club to Port Vincent. The unit of energy is a joule.

Power (symbol W) is the rate of doing work or the rate at which energy is converted from one form to another, for example an electrical motor converting electrical energy to mechanical energy. The unit of power is a watt (joule per second). Examples are the power of a light globe or engine (usually measured in thousands of watts or kilowatts, kW, or in imperial units of horsepower).

So, the critical measure for radar performance is the amount of radio energy it places on a target, not the power.

Energy (joules) = Transmit Power (watts) x Transmit Pulse Duration (seconds)

## Modulation

Modulation[4] is the process of varying one or more properties of a (radio) signal with a modulating factor. An example is a musician who modulates a note by varying its volume or pitch. Likewise, a broadcast radio station modulates its radio signal with voice or music and your receiver amplifies and extracts (or demodulates) the voice or music. In AM broadcasts, the amplitude of the radio wave is modulated whereas in FM, including marine VHF, the frequency of the radio wave is modulated.

In the case of the Navico "broadband" radar, the frequency of the pulse is linearly increased throughout the transmit pulse. The receiver searches for echoes whose frequency increases in exactly the same way as the transmit pulse. By the way, other radars such as the Jindalee Over the Horizon Radar use the same principle[5] although they use more sophisticated digital modulation techniques.